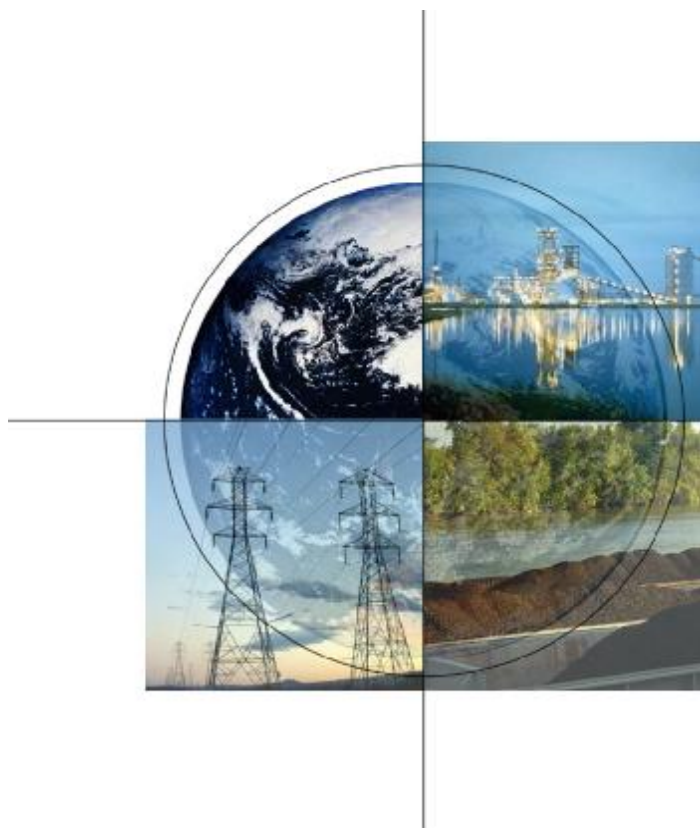


Gasification – Versatile Solutions for Issues Today and Tomorrow



*Montana Energy
Symposium*

October 18, 2005

Carl O. Bauer, Director

National Energy Technology Laboratory



Office of Fossil Energy

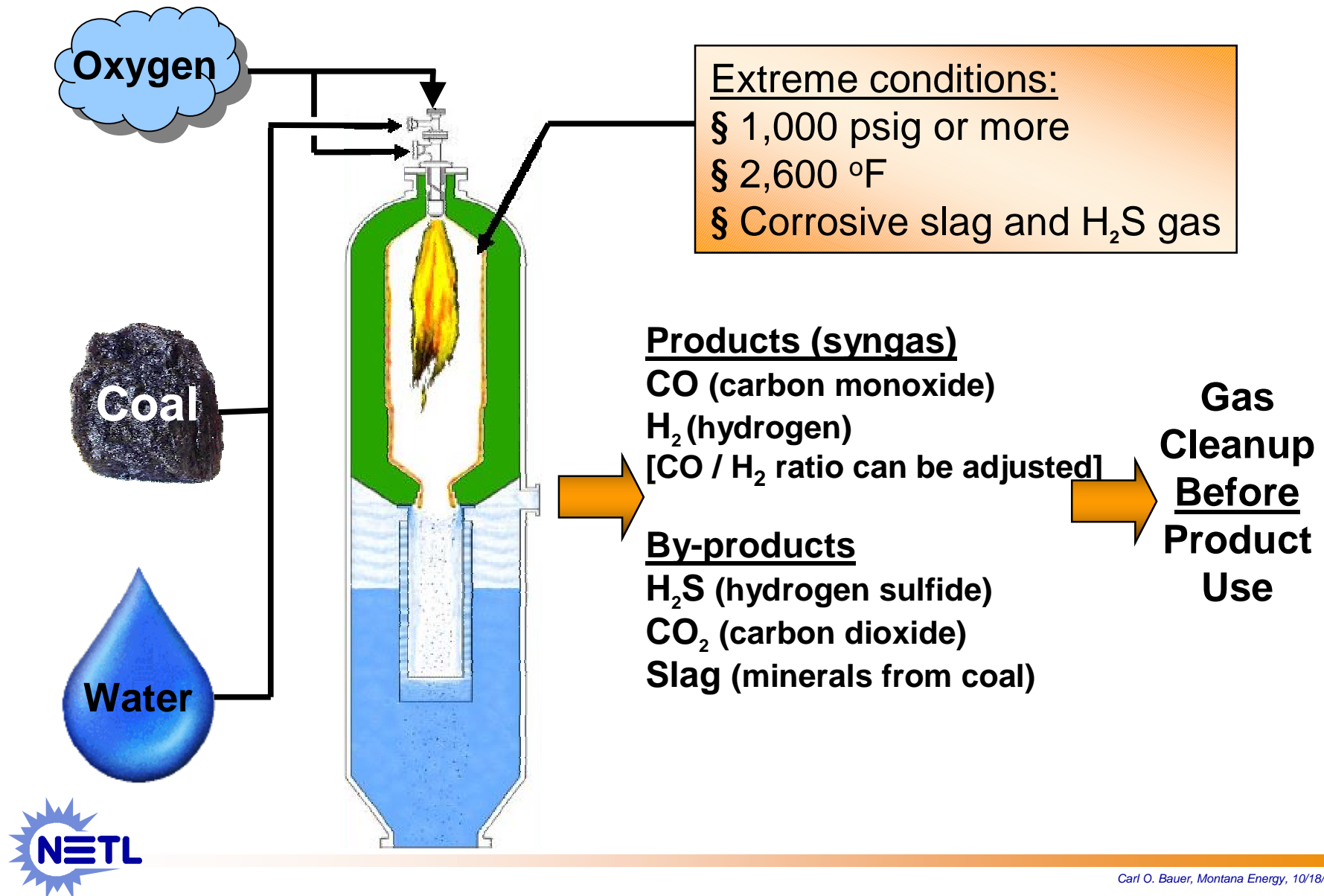


Why the Interest in Gasification?

- Continuing high price of natural gas
- Excellent environmental performance of IGCCs
- Growing environmental community view of IGCCs as BACT for coal systems
- Consolidation of IGCC development companies
- Uncertainty of carbon management requirements and potential suitability of IGCC for CO₂ controls



What Is Gasification?



Energy Bill 2005

Funding Involving Gasification Technology

- **Authorizations**

- Clean Coal Power Initiative
\$1.8B with minimum 70% gasification
- Clean Power Projects
\$505M identified (several IGCC specified) with \$425M gasification
- Clean Air Coal Program
\$2.5B generation and \$0.5B air quality
- Coal Research Program
\$1.13B

***Total directly or indirectly related to gasification technology –
\$7 billion plus cost-of-loan guarantees and specified projects***



Energy Bill 2005

Funding Involving Gasification Technology

- **Incentives**

- Energy policy tax incentives
 - \$800M gasification; \$500M advanced combustion
 - \$350M industrial gasification
- Incentives for innovative technologies
 - Appropriations as necessary to cover cost-of-loan guarantees
 - Western coal IGCC project specified

***Total directly or indirectly related to gasification technology –
\$7 billion plus cost-of-loan guarantees and specified projects***



Gasification Possible for Montana?

- Abundant, inexpensive source of quality low-rank, low-sulfur coal
- Availability of potential sites for sequestration of carbon emissions
- Quality labor for both mining and plant operations requirements
- Benefits to Montana citizens
 - Job creation
 - Revenue enhancement
- Creation of new industries for fuels and H₂ that are high in value-added products



Properties of U.S Coals

	Wyoming Subbituminous <i>Spring Creek</i>	Montana Subbituminous <i>Decker</i>	N. Dakota Lignite <i>Freedom</i>	Texas Lignite <i>S. Hallsville</i>
Heating Value, Btu / lb (as received)	9,190	9,540	7,090	7,080
Proximate, wt%:				
Moisture	24.1	23.4	33.3	37.7
Volatile matter, dry	43.1	40.8	43.6	45.2
Fixed carbon, dry	51.2	54.0	45.3	44.4
Ash, dry	5.7	5.2	11.1	10.4
Ultimate, wt% moisture free:				
Carbon	70.3	72.0	63.3	66.3
Hydrogen	5.0	5.0	4.5	4.9
Nitrogen	0.96	0.95	1.0	1.0
Sulfur	0.35	0.44	1.1	1.2
Ash	5.7	5.2	11.1	10.4
Oxygen	17.69	16.41	19.0	16.2



*"Steam – Its Generation and Use,"
Babcock & Willcox*

Carl O. Bauer, Montana Energy, 10/18/05

Montana Gasification Issues

- Predictability of gasification with low-rank coals
- Reliability of coal feed system for use with low-rank coal feeding high-pressure gasifiers
- Influence of high moisture and ash content on process thermal performance



Montana Gasification Issues

- Availability of gasifier for efficient performance with low-rank coals
- Thermal performance penalties with low rank coals at high altitudes



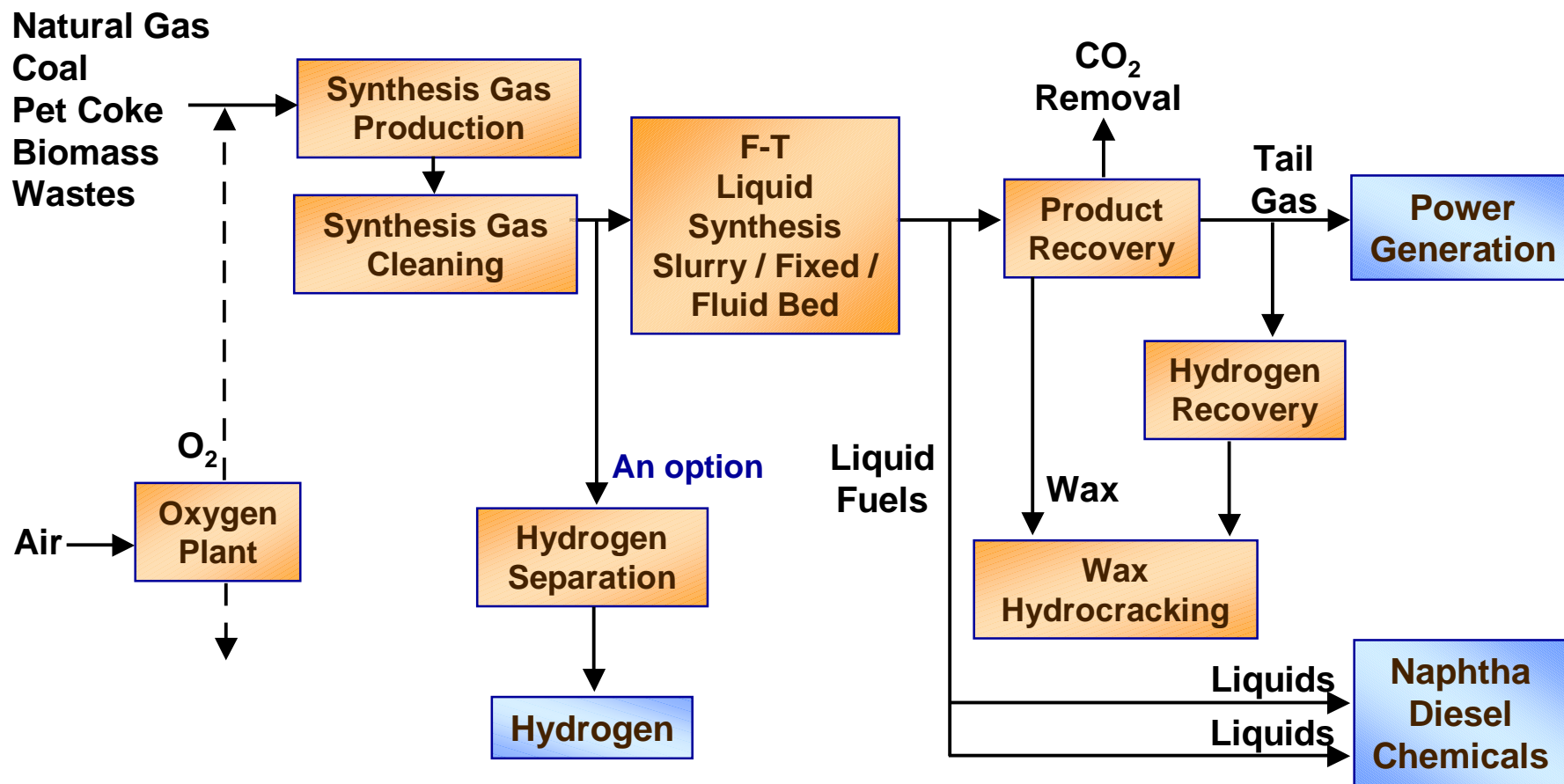
Six Major Direct Uses of Synthesis Gas

Primary Product

Methanol synthesis (commercial)	Methanol
Fischer-Tropsch synthesis (commercial: S. Africa / Malaysia)	Fuels and specialty chemicals
Isosynthesis (not commercial)	Branched paraffins
Combustion (commercial)	Electricity / heat
Methanation (one commercial plant in U.S.)	Synthetic natural gas (SNG)
Hydrogen production	Refining / ammonia / fuel for fuel cells

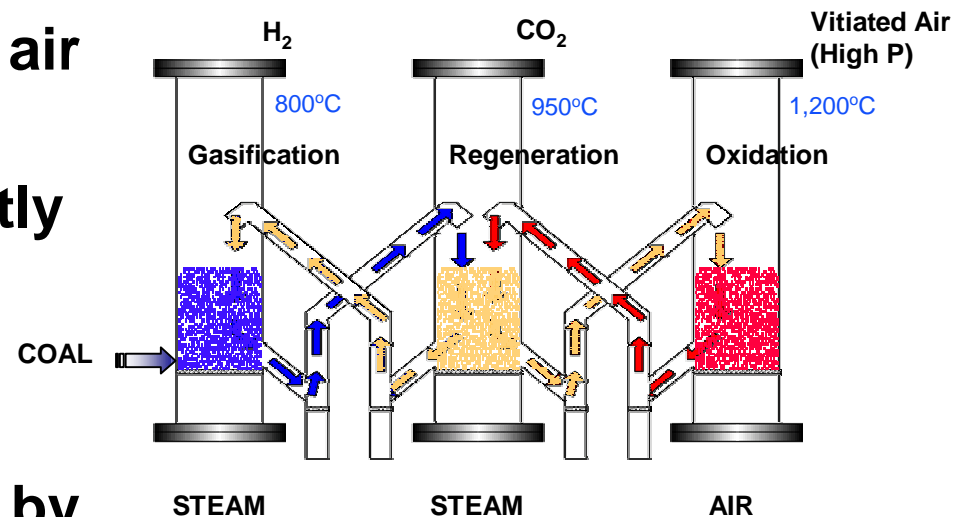


Co-Production Technology Overview

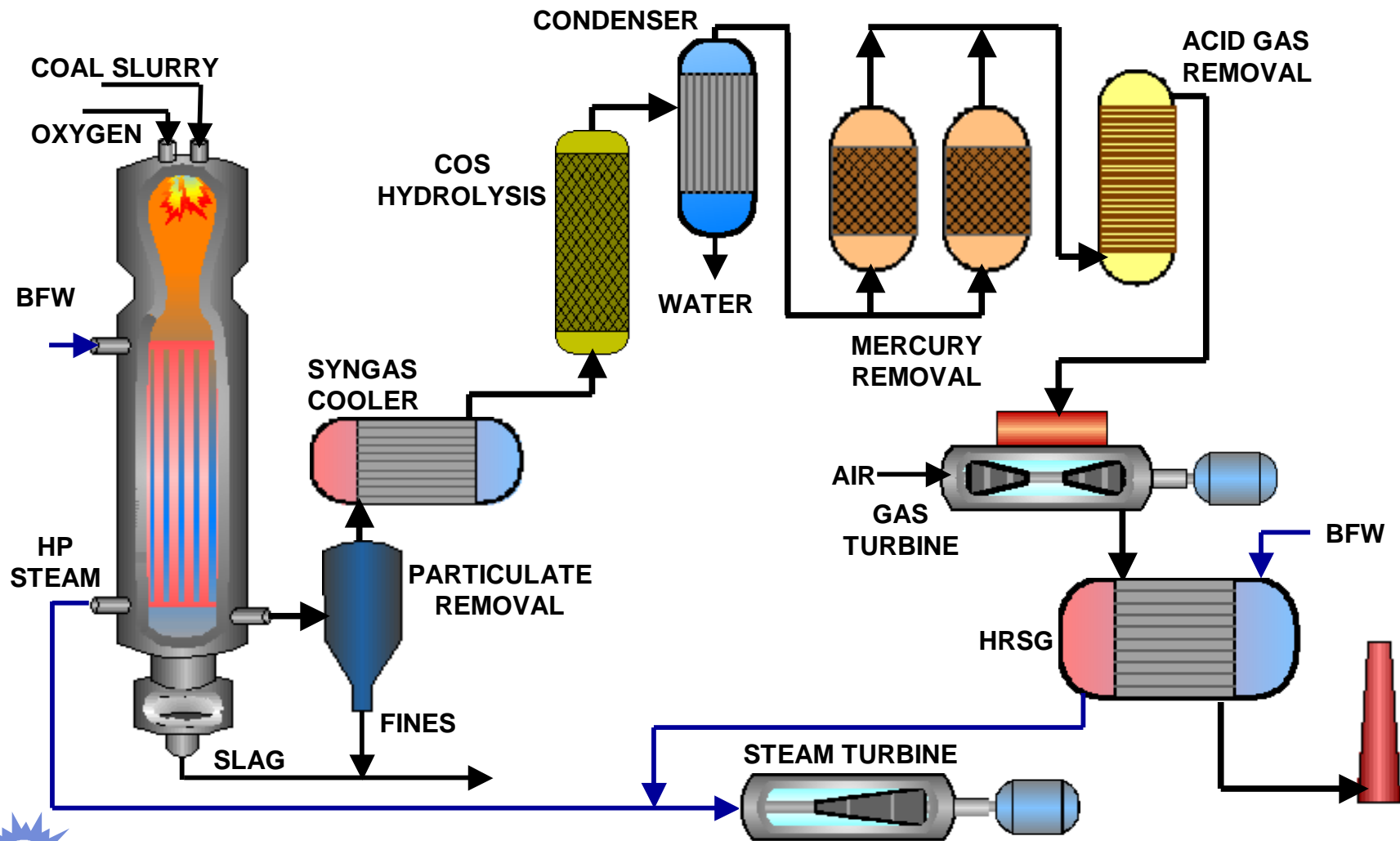


Gasification Through Chemical Looping

- Efficient, cost-effective process capable of both oxygen-fired combustion and gasification without expensive cryogenic air separation unit
- In gasification mode, efficiently produces hydrogen for gas turbines, fuel cells, or other applications
- Combustion option achieved by removing gasification reactor
- NETL currently working with 2 contractors – GE and Alstom



IGCC with Mercury Removal



Mercury Removal System

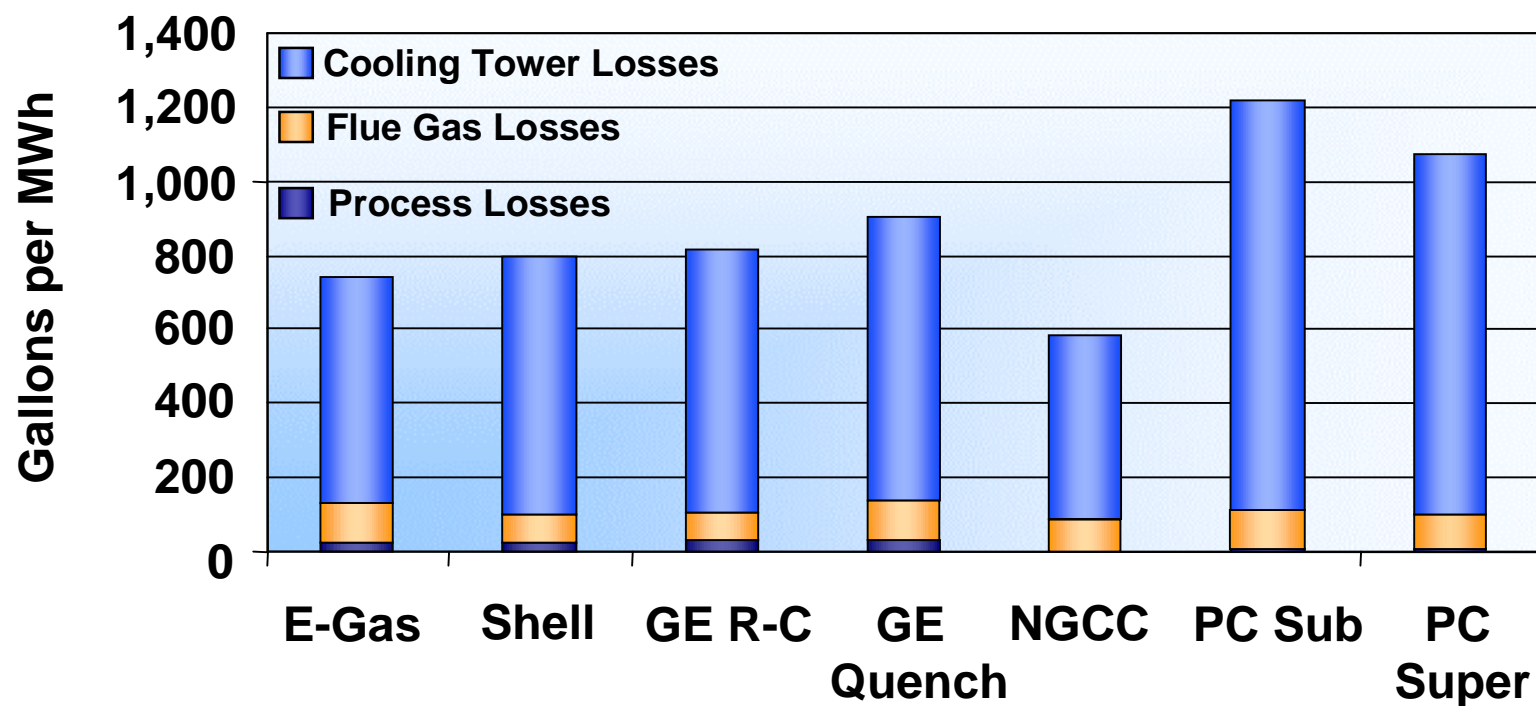
Performance and Cost

- Remove greater than 90% of mercury
- Stable adsorption of mercury in carbon beds as mercury sulfide
- Incremental capital costs of \$3.34 / kW for carbon-bed removal system
- Incremental cost of electricity of \$0.254 / MWh for O&M and capital repayment
 - <0.6% COE from IGCC plant of \$44 / MWh
 - Estimated cost of mercury removal in IGCC compares favorably (<10%) to costs of 90% removal in conventional PC power plant

Estimates for IGCC reference plant based on Tampa Electric Gasification Plant with GE Energy gasifier and sized to 287-MWe net



Comparison of Water Consumption for Various Fossil Plants

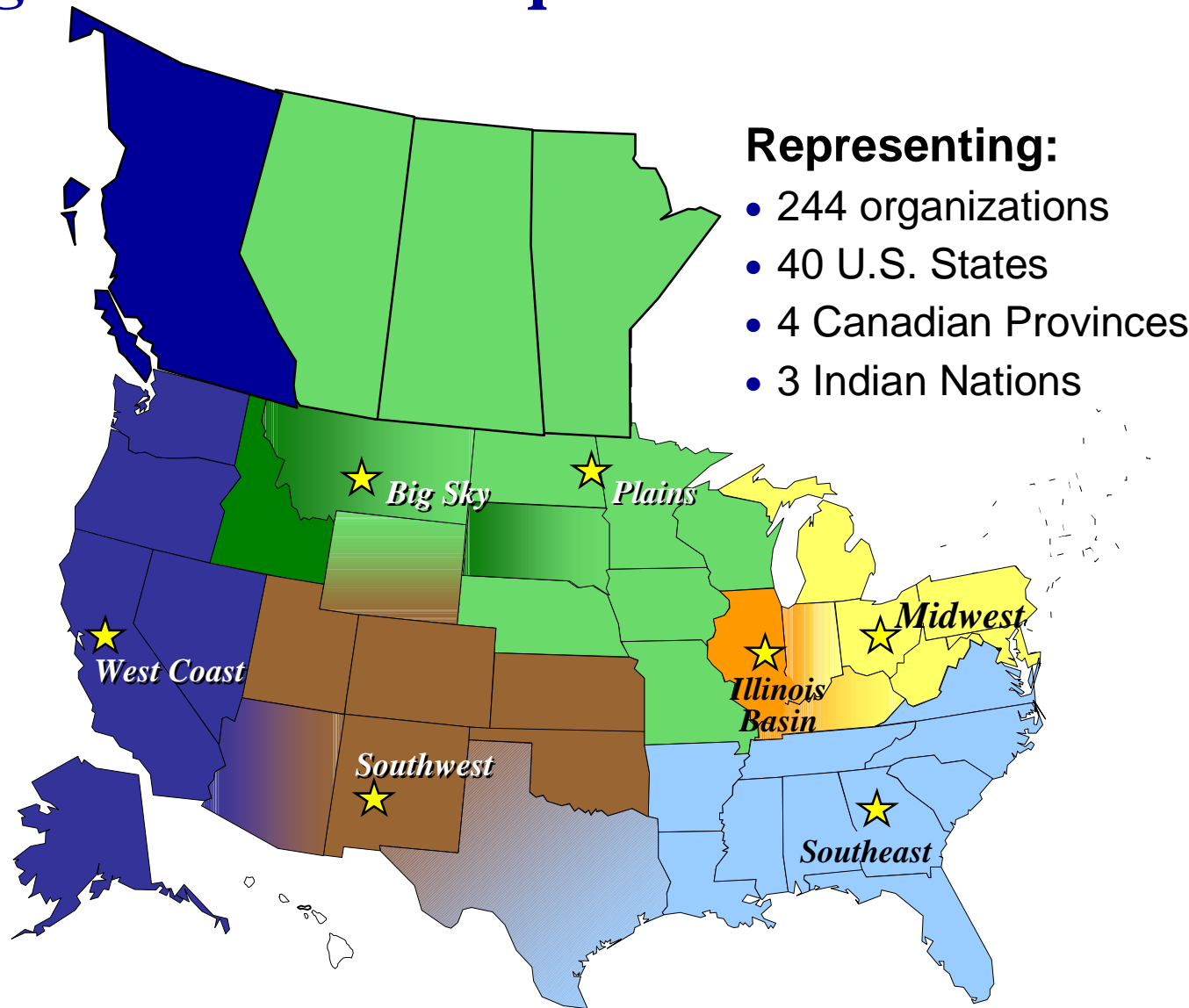


Note: Cooling water requirements are estimated for generic eastern site, not Montana

Carl O. Bauer, Montana Energy, 10/18/05



Regional Carbon Sequestration Partnerships



Visit NETL Websites

The image displays two screenshots of the National Energy Technology Laboratory (NETL) website. The left screenshot is for the Carbon Sequestration section, featuring a blue header with the NETL logo and navigation links. The main content area includes a welcome message, a vision statement, and a list of resources. The right screenshot is for the Gasification section, featuring a blue header with the NETL logo and navigation links. The main content area includes a description of gasification technologies, a list of advanced gasification technologies, and a section for latest news.

Carbon Sequestration

Pathways to Sustainable Use of Fossil Fuels—enabling the removal and permanent storage of carbon dioxide from fossil-energy systems

Welcome to NETL's Carbon Sequestration Webpage.

Our vision is to possess the scientific understanding of carbon sequestration options, providing cost-effective, environmentally-sound technology options that ultimately lead to a reduction in greenhouse gas intensity. We conduct core R&D in carbon capture, sequestration, measurement monitoring and verification, breakthrough concepts, and non- CO_2 greenhouse gas control. Regional partnerships create sequestration infrastructure, and FutureGen, an integrated sequestration and hydrogen production initiative, will demonstrate sequestration at a power plant scale. For more information about our program, see the [Overview](#). Our site is designed to answer your

Gasification

A program to deliver clean, secure, and affordable energy systems

Gasification Technologies can provide a stable, affordable energy supply for the nation. Gasification-based systems provide high efficiency with near zero pollutants. They provide flexibility in the production of a wide range of products including electricity, fuels, chemicals, hydrogen, and steam. And perhaps most important, in a time of electricity- and fuel-price spikes, flexible gasification systems provide for operation on low-cost, widely-available feedstocks.

As you view the various pages of this web site, you will learn about the Gasification Program and its goals, current projects and solicitations, development facilities, system and market studies, and databases. We hope that the information provided will prove to be a valuable resource for you. We welcome any [suggestions, comments, or questions](#) about the information contained on this

LATEST NEWS:

- ▶ [DOE Advances Code of Climate Change](#)
- ▶ [Sign up now for Be Sequestration](#) (PDF)
- ▶ [Regional Partnership](#)
- ▶ [English translation](#)

Advanced Gasification Technologies

- Advanced Gasification
- Gas Cleaning & Conditioning
- Advanced Gas Separation
- Product & By-Product Utilization
- Systems Analysis/Tech. Integration
- Technology Demonstration
- Development Facilities

MOVING TOWARDS IGCC COMMERCIALIZATION

www.netl.doe.gov

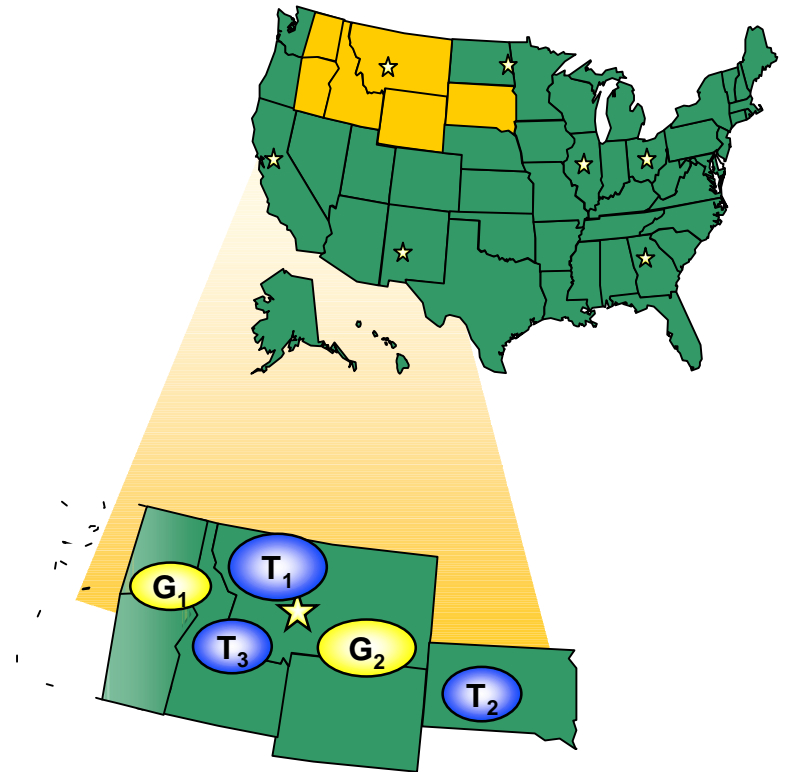


Additional Slides



Big Sky Regional Carbon Sequestration Partnership – Montana State University

- Over 50 participating organizations
- Basalt formations offer large storage capacity > 100 GT
- Many opportunities for value-added benefits
 - Oil and gas fields
 - Coal seams
- 40% of U.S. coal reserves within the region
- CO₂ EOR operational experience within the region
- Phase II Pilot to demonstrate permanent storage via mineralization in basalt formations



Montana Oil and Natural Gas Resources

- **Economic advantages of additional hydrocarbon production may result in oil and natural gas fields among the first sites selected for sequestration**
 - Oil production: 19,300,000 barrels per year
 - Natural gas production: 78,200 million cubic feet per year
 - No. of Class II Wells: 100–5,000 (saline formations)



Montana Coal Resources

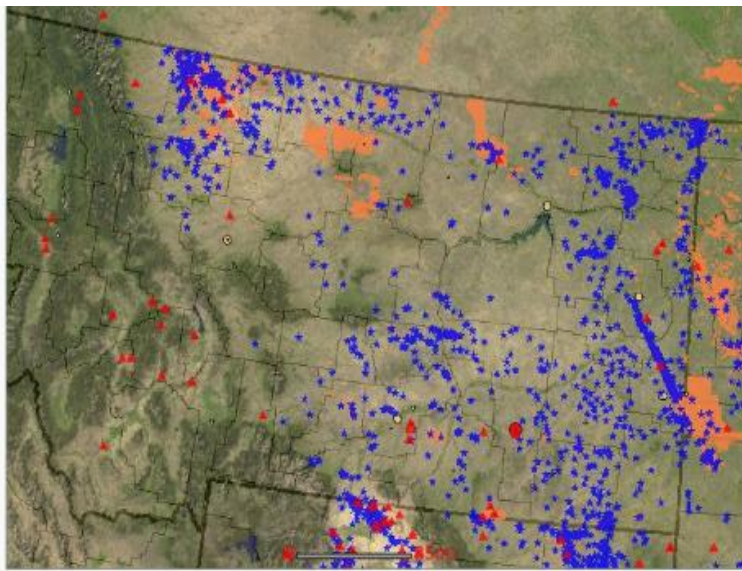
- **Montana is capable of handling power plant volumes in region while adding to employment and commerce**
- **Montana among top 10 coal-producing states**

Thousand Short Tons (July 2005)	YTD 2005
Wyoming	235,233
West Virginia	87,324
Kentucky	66,759
Pennsylvania	38,194
Texas	25,404
Colorado	24,001
Montana	21,610
Indiana	19,218
Illinois	17,603
Virginia	17,078
U.S. Total	645,324

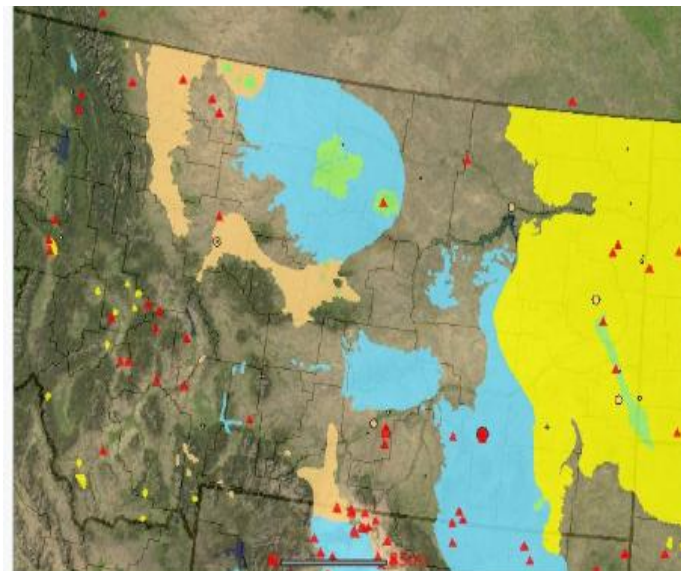


CO₂ Sources and Potential Geologic Sequestration Formations in Montana

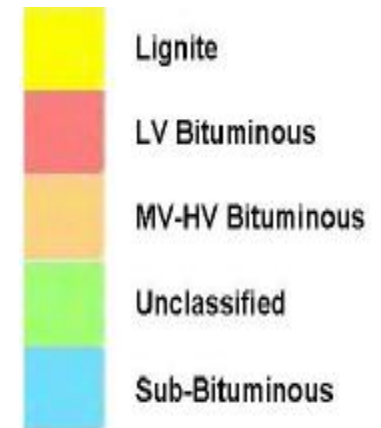
- Large number of saline formations are concentrated within Montana
- Western oil and natural gas fields are concentrated to some degree in Montana



CO₂ Sources, Saline, and Oil and Natural Gas Formations

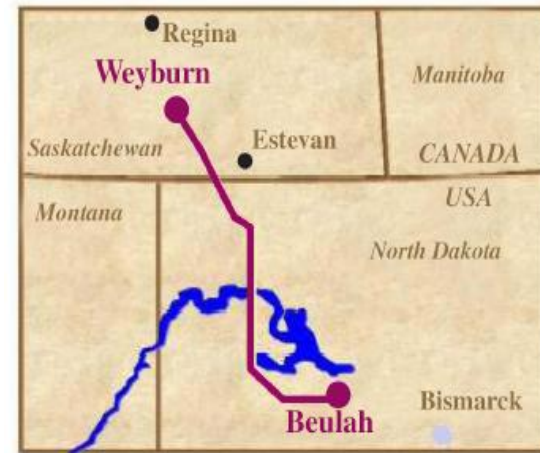


CO₂ Sources and Coal Formations



Opportunities Exist for CO₂ Utilization

Weyburn Example: Existing CO₂ Pipeline Infrastructure

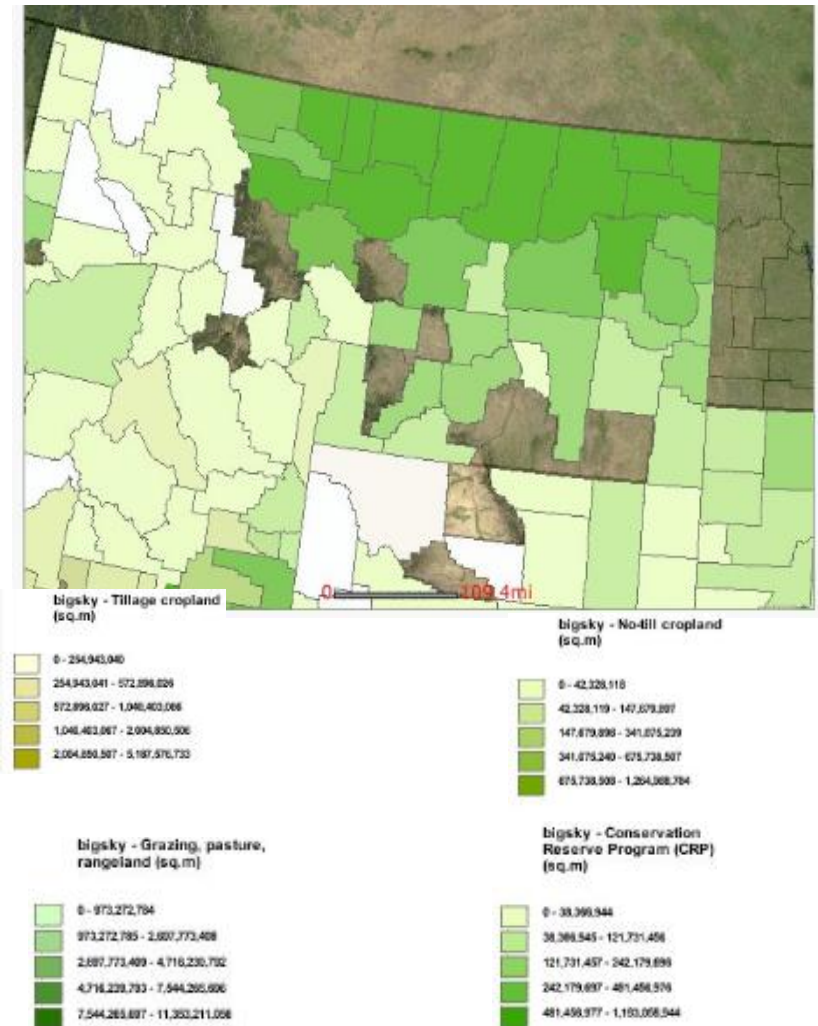


Pipeline Route from North Dakota Gasification Plant to Weyburn Oil Field

- 5,000 tons / day CO₂
- 204-mile CO₂ pipeline from Dakota Gasification Plant
- 130M barrels oil over 20-year project
- 1M tons / year CO₂ sequestered

Terrestrial Sequestration Potential in Montana

- No-till continuous cropping and use of cover crops are promising cropland management approaches to soil carbon increases
- Potential increase in carbon sequestration for approximately 25% increase in use of no-till for Montana



Funding Involving Gasification Technology

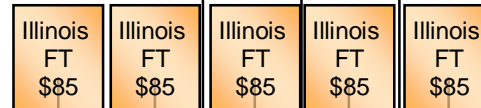
Authorizations (\$M or as specified)

Clean Air Coal Program (Generation / Air Quality)



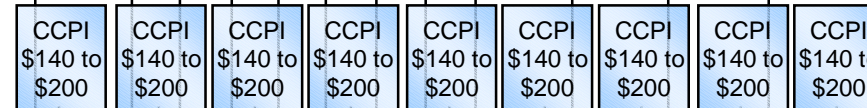
Total
\$2.5 billion (generation)
\$500 million (air quality)

Fisher Tropsch



Total
\$425 million (grants or
cost sharing)

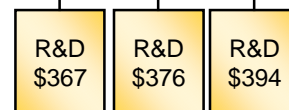
CCPI



**Total \$1.26 to
\$1.8 billion**



Coal Research Program



Total
\$1.137 billion



9 Specified IGCC Projects

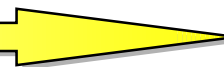


**Appropriations as
necessary**

Energy Policy Tax Incentives



20% ITC for IGCC



Total
\$800 million limit



20% ITC for Industrial Gasification



Total
\$350 million limit

Incentives for Innovative Technologies



80% Loan Guarantees



**Appropriations as
necessary**

Incentives



Concept for Polygeneration Plant With Distribution of Products *SNG, H₂, Electricity, CO₂*

